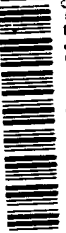


06/22/00



jc849 U.S. PRO

06-23-00

A

CONTINUATION APPLICATION TRANSMITTAL FORM

PATENT
Docket No: 97-3-802CON1
Prior Application 09/050,680

jc836 U.S. PRO
09/602079
06/22/00

Anticipated Classification
Of this Application:

Class	SubClass	Examiner	Art Unit
<u>455</u>	<u>447</u>	<u>Q. Vuong</u>	<u>2744</u>

To the Commissioner of Patents and Trademarks:

This is a request for filing a Continuation of a utility application under 37 CFR 1.53(b), of pending prior application Serial Number 09/050,680 filed on 3/30/1998 for SYSTEM AND METHOD FOR INCREASING CDMA CAPACITY currently pending (Parent).
The benefit of an earlier filing date under 35 U.S.C. §120 is claimed.

Certification Under 37 CFR 1.10

I hereby certify that this New Application Transmittal and the documents referred to as enclosed therein are being deposited with the United States Postal Service on this date 6/22/00 in an envelope as "Express Mail Post Office to Addressee" mailing label Number EK092690216US addressed to the: Assistant Commissioner for Patents, Box Patent Application, Washington, D.C. 20231.

Mary E. Anza
(typed or printed name of person mailing paper)
Mary E. Anza
(Signature of person mailing paper)

NOTE: Each paper or fee referred to as enclosed herein has the number of the "Express Mail" mailing label placed thereon prior to mailing. 37 CFR 1.10(b).

Warning: Certificate of mailing (first class) or facsimile transmission procedures of 37CFR1.8 cannot be used to obtain a date of mailing or transmission for this correspondence.

1. X Enclosed is a copy of the latest inventor-signed prior application, including the oath or declaration as originally filed. I hereby verify that the attached papers are a true copy of the latest inventor-signed prior application Serial No. 09/050,680 as originally filed on 3/30/98 and further that all statements made herein of their own knowledge and true and that all statements made on information and belief are believed to be true; and further that these statements and the like are so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.
2. X Enclosed is an Information Disclosure Statement.
3. X Cancel in this application claims 2-6, 8, 10-12, 14-18, 20 of the prior original application before calculating the filing fee (At least one original independent claim must be retained for filing purposes).
4. X enclosed is a Preliminary Amendment to the Application.

5. The filing fee is calculated below based on the claim structure resulting from the enclosed Preliminary Amendment:


BASIC FEE				\$690.00
FOR	NUMBER FILED	NUMBER EXTRA	RATE	FEE
TOTAL CLAIMS	11	0	\$18.00	0.00
INDEPENDENT CLAIMS	10	7	\$78.00	546.00
TOTAL FILING FEE				1236.00

6. X The Commissioner is hereby authorized to charge the filing fee, any additional fees, which may be required, or credit any overpayment to Deposit Account No. **07-2339**. A duplicate copy of this sheet is enclosed.
7. X 9 sheets of original informal drawings are enclosed.
8. X The prior application is assigned of record to: GTE Laboratories Incorporated at Reel 9131, Frame 0215, a copy of the Assignment is enclosed.
9. The power appears in the parent (09/050,680) application (copy enclosed).
10. Also enclosed, notification for the parent case that continuation is being filed.
11. Address all future communications to:

Leonard Charles Suchyta, Esq.
GTE Service Corporation
600 Hidden Ridge HQE03G13
Irving, TX 75038

[illegible]

6-21-00
(Date)


W. Eric Webostad
Reg. No. 35,406

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"Express Mail" mailing label number EK092690216US

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I hereby certify that this paper or fee is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above and is addressed to the Commissioner of Patents and Trademarks, Washington, D.C. 20231.

Mary E Anza

(Typed or printed name of person mailing paper or fee)

Mary E Anza
(Signature of person mailing paper or fee)

PATENT
U.S. Patent Application No. Not Yet Assigned
Attorney's Docket No. 97-3-802CON1

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of)
Vincent A. O'BYRNE)
Application No.: Not Yet Assigned) Group Art Unit: Not Yet Assigned
Filed: Concurrently Herewith) Examiner: Not Yet Assigned
For: SYSTEM AND METHOD FOR)
INCREASING CDMA CAPACITY BY)
FREQUENCY ASSIGNMENT)

PRELIMINARY AMENDMENT

Commissioner for Patents
Washington, D.C. 20231

Sir:

Prior to Examination on the merits, please amend the application as follows:

IN THE CLAIMS:

Please amend the claims as follows:

1. (Amended) A method for increasing capacity of a [digital] wireless network having a plurality of cell sites, comprising the steps of:

defining a pool of available frequencies [available] for assignment; [and]

assigning [one of the] an available frequency [frequencies] from the [frequency] pool of available frequencies to each [of the] cell site[s] of the plurality of cell sites, the available frequency assigned to limit [based on frequencies assigned to neighboring cell sites to minimize a number of] neighboring cell sites assigned a same [one of the available frequencies] frequency as the available frequency;

determining signal quality parameters associated with at least one cell site of the plurality of cell sites; and

modifying the pool of available frequencies for assignment based on the determined signal quality parameters associated with the at least one cell site.

7. (Amended) A system for increasing capacity of a [digital] wireless network having a plurality of cell sites, comprising:

a frequency defining component to define a pool of available frequencies [available] for assignment; [and]

an assignment component to assign [one of the] an available frequency[ies] from the [frequency] pool of available frequencies to each [of the] cell site[s] of the plurality of cell sites, the available frequency [based on frequencies] assigned to limit [neighboring cell sites to minimize a number of] neighboring cell sites assigned a same [one of the available frequencies] frequency as the available frequency;

a determination component to determine signal quality parameters associated with at least one cell site of the plurality of cell sites; and

a frequency component to modify the pool of available frequencies for assignment based on the determined signal quality parameters associated with the at least one cell site.

13. (Amended) A computer program product for increasing capacity of a [digital] wireless network having a plurality of cell sites, comprising:

a frequency defining module to define a pool of available frequencies [available] for assignment; [and]

an assignment module to assign [one of the] an available frequency[ies] from the [frequency] pool of available frequencies to each [of the] cell site[s] of the plurality of cell sites, the available frequency to [minimize a number of] limit neighboring cell sites assigned a same [one of the available frequencies] frequency as the available frequency;

a determination module to determine signal quality parameters associated with at least one cell site of the plurality of cell sites; and

a frequency module to modify the pool of available frequencies for assignment based on the determined signal quality parameters associated with the at least one cell site.

19. (Amended) A method of increasing capacity of a [digital] wireless network, comprising the steps of:

- identifying cell sites of the [digital] wireless network;
- defining a pool of available frequencies [available] for assignment;
- selecting one of the cell sites;
- determining frequencies assigned to the cell sites neighboring the selected cell site to provide determined frequencies; [and]
- assigning one of the available frequencies to the selected cell site based on the determined frequencies [assigned to the neighboring cell sites to minimize] to limit a number of neighboring cell sites assigned a same one of the available frequencies;
- determining signal quality parameters associated with at least one cell site of the plurality of cell sites; and
- modifying the pool of available frequencies for assignment based on the determined signal quality parameters associated with the at least one cell site.

Please add the following claims:

- - 21. A method for increasing capacity of a wireless network having a plurality of cell sites, comprising the steps of:

assigning an available frequency from a pool of available frequencies to each cell site of the plurality of cell sites;

increasing the pool of available frequencies for assignment to reduce an amount of interference at at least one cell site of the plurality of cell sites; and

assigning the increased pool of available frequencies to the cell sites to limit the number of neighboring cell sites assigned the same one of the available frequencies.

22. A system for increasing capacity of a wireless network having a plurality of cell sites, comprising:

a frequency defining component to define a pool of available frequencies for assignment;

an assignment component to assign an available frequency from the pool of available frequencies to each cell site of the plurality of cell sites;

a frequency component to increase the pool of available frequencies for assignment to reduce an amount of interference at at least one cell site of the plurality of cell sites; and

a frequency assignment component to assign the increased pool of available frequencies to the cell sites to limit the number of neighboring cell sites assigned the same one of the available frequencies.

23. A computer program product for increasing capacity of a wireless network having a plurality of cell sites, comprising:

a frequency defining module to define a pool of available frequencies for assignment;

an assignment module to assign an available frequency from the pool of available frequencies to each cell site of the plurality of cell sites;

a frequency module to increase the pool of available frequencies for assignment to reduce an amount of interference at at least one cell site of the plurality of cell sites; and

a frequency assignment module to assign the increased pool of available frequencies to the cell sites to limit the number of neighboring cell sites assigned the same one of the available frequencies.

24. A method for increasing capacity of a wireless network having a plurality of cell sites, comprising the steps of:

assigning an available frequency from a pool of available frequencies to each cell site of the plurality of cell sites;

determining an amount of interference at at least one cell site of the plurality of cell sites;

modifying the pool of available frequencies for assignment based on the determined amount of interference; and

assigning the modified pool of available frequencies to the cell sites to limit the number of neighboring cell sites assigned the same one of the available frequencies.

25. A system for increasing capacity of a wireless network having a plurality of cell sites, comprising:

an assignment component to assign an available frequency from a pool of available frequencies to each cell site of the plurality of cell sites;

a determination component to determine an amount of interference at at least one cell site of the plurality of cell sites;

a frequency component to modify the pool of available frequencies for assignment based on the determined amount of interference; and

a frequency assignment component to assign the modified pool of available frequencies to the cell sites to limit the number of neighboring cell sites assigned the same one of the available frequencies.

26. A computer program product for increasing capacity of a wireless network having a plurality of cell sites, comprising:

an assignment module to assign an available frequency from a pool of
available frequencies to each cell site of the plurality of cell sites;

a determination module to determine an amount of interference at at least one
cell site of the plurality of cell sites;

a frequency module to modify the pool of available frequencies for assignment
based on the determined amount of interference; and

a frequency assignment module to assign the modified pool of available
frequencies to the cell sites to limit the number of neighboring cell sites assigned the same
one of the available frequencies. - -

REMARKS

This Preliminary Amendment amends claims 1, 7, 13 and 19 and adds new claims 21-

26. Favorable examination and allowance of the pending claims are respectfully solicited.

If there are any fees due in connection with the filing of this response, please charge the fees to our Deposit Account No. 07-2339. If an extension of time under 37 C.F.R. § 1.136 not accounted for above, is required, such an extension is requested and the fee should also be charged to our Deposit Account.

Respectfully submitted,

By: 

W. Eric Webostad

Registration No. 35,406

Date: 6-21-00

GTE Service Corporation
600 Hidden Ridge, HQE03G13
Irving, Texas 75038
781-466-4013

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100	2101	2102	2103	2104	2105	2106	2107	2108	2109	2110	2111	2112	2113	2114	2115	2116	2117	2118	2119	2120	2121	2122	2123	2124	2125	2126	2127	2128	2129	2130	2131	2132	2133	2134	2135	2136	2137	2138	2139	2140	2141	2142	2143	2144	2145	2146	2147	2148	2149	2150	2151	2152	2153	2154	2155	2156	2157	2158	2159	2160	2161	2162	2163	2164	2165	2166	2167	2168	2169	2170	2171	2172	2173	2174	2175	2176	2177	2178	2179	2180	2181	2182	2183	2184	2185	2186	2187	2188	2189	2190	2191	2192	2193	2194	2195	2196	2197	2198	2199	2200	2201	2202	2203	2204	2205	2206	2207	2208	2209	2210	2211	2212	2213	2214	2215	2216	2217	2218	2219	2220	2221	2222	2223	2224	2225	2226	2227	2228	2229	2230	2231	2232	2233	2234	2235	2236	2237	2238	2239	2240	2241	2242	2243	2244	2245	2246	2247	2248	2249	2250	2251	2252	2253	2254	2255	2256	2257	2258	2259	2260	2261	2262	2263	2264	2265	2266	2267	2268	2269	2270	2271	2272	2273	2274	2275	2276	2277	2278	2279	2280	2281	2282	2283	2284	2285	2286	2287	2288	2289	2290	2291	2292	2293	2294	2295	2296	2297	2298	2299	2300	2301	2302	2303	2304	2305	2306	2307	2308	2309	2310	2311	2312	2313	2314	2315	2316	2317	2318	2319	2320	2321	2322	2323	2324	2325	2326	2327	2328	2329	2330	2331	2332	2333	2334	2335	2336	2337	2338	2339	2340	2341	2342	2343	2344	2345	2346	2347	2348	2349	2350	2351	2352	2353	2354	2355	2356	2357	2358	2359	2360	2361	2362	2363	2364	2365	2366	2367	2368	2369	2370	2371	2372	2373	2374	2375	2376	2377	2378	2379	2380	2381	2382	2383	2384	2385	2386	2387	2388	2389	2390	2391	2392	2393	2394	2395	2396	2397	2398	2399	2400	2401	2402	2403	2404	2405	2406	2407	2408	2409	2410	2411	2412	2413	2414	2415	2416	2417	2418	2419	2420	2421	2422	2423	2424	2425	2426	2427	2428	2429	2430	2431	2432	2433	2434	2435	2436	2437	2438	2439	2440	2441	2442	2
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GTE Ref. No. 97-3-802
Attorney Docket No. 6592.0033-00

OF

FOR

SYSTEM AND METHOD FOR INCREASING CDMA CAPACITY BY FREQUENCY ASSIGNMENT

FIELD OF THE INVENTION

The present invention relates generally to wireless communications systems and more particularly to a method for increasing the capacity of a Code Division Multiple Access (CDMA) network.

5

BACKGROUND OF THE INVENTION

A CDMA cellular network is a digital spread spectrum communications system. The CDMA network includes several base stations each providing digital service to mobile units located in different geographical regions. Communication between a mobile unit and a base station in a CDMA network occurs on reverse and forward CDMA channels. The reverse channel is a mobile unit-to-base station direction of communication that carries traffic and signaling information. The forward channel is a base station-to-mobile unit direction of communication that carries pilot, sync, and paging signals in addition to traffic signals.

CDMA networks are deployed differently from analog and other digital networks.

CDMA networks are typically deployed with the ability to operate at only one frequency because additional frequencies, though possible, require additional hardware. To increase coverage area, conventional CDMA networks use one common frequency transmission and soft handoff mechanisms. This results in approximately a 3-4 dB advantage in the transmission channel budget, and thus, a larger cell site size for deployment purposes.

Handoffs typically occur when mobile or portable units traverse the cell sites of the network. A "soft handoff" is when the mobile unit begins communication with a new base station on the same CDMA frequency assignment before terminating communication with the old base station. A "hard handoff," on the other hand, is characterized by a temporary

disconnection of the mobile unit's Traffic Channel. Hard handoffs occur, for example, when the CDMA frequency assignment changes or when the mobile unit is directed from a CDMA Traffic Channel to an analog voice channel.

The capacity of a CDMA network is a complex function of the handoff condition of the network, the propagation environment, and the loading of the surrounding cell sites. In a typical CDMA network, the capacity on the reverse channel is limited by interference from mobile units operating in other cell sites. This cuts the capacity on the reverse channel by about 30 to 40% in a typical propagation environment with a pathloss exponent of 3.5 to 4. The reduction in capacity on the reverse channel is measured in terms of a frequency reuse factor. Fig. 1 is a graph of the frequency reuse factor as a function of the pathloss exponent in a CDMA network deployed at a single frequency.

In some circumstances, intracell interference significantly reduces the capacity of the CDMA network, especially when the propagation coefficient is very low (*i.e.*, pathloss exponents of 1 or 2, which equates to 10 or 20 dB reductions in signal strength per decade change in distance). In these circumstances, a majority of the signal received at the base station is a result of interference from other cell sites. This limits the capacity of the CDMA network.

The maximum reverse channel capacity, or pole capacity, is a function of many CDMA parameters and can be expressed approximately by

$$N = \frac{W}{R} * \frac{1}{\frac{E_b}{N_o}} * \frac{1}{d} * F * G \quad (1)$$

where N represents the number of users, W is the signal bandwidth (*e.g.*, 1.23 MHz), R is the information rate (*e.g.*, 9.6 kbps or 14.4 kbps for Rate Set I or Rate Set II), E_r/N_o is the received signal relative to the noise level (typically 7 dB), d is the voice activity factor, F is the frequency reuse factor (*i.e.*, the ratio of in-band to out-of-band interference), and G is the sectorization gain (*e.g.*, 2.55 for a 120 degree antenna).

A typical set of parameters, where d = 40%, R = 9.6 kbps, and F = 0.6, results in 38 channels per frequency channel (1.23 MHz). CDMA networks typically operate at 50% reverse channel capacity, which means that the network realizes approximately 19 traffic channels per carrier.

The frequency reuse factor (F) is defined as

$$F = \frac{\text{Intracell Interference}}{\text{Intracell Interference} + \text{Inter-cell Interference}} \quad (2)$$

Intracell Interference represents interference caused by mobile units operating within the cell site, and Inter-cell Interference represents interference caused by mobile units operating within other cell sites. Inter-cell Interference detracts from the usable capacity of the network, and must be reduced to increase the frequency reuse factor to its theoretical maximum of unity.

Today, CDMA network operators are granted a greater frequency bandwidth than actually used to deploy the CDMA network. However, these operators continue to deploy a single frequency and use the benefits of soft handoffs to improve call quality. Soft handoffs are typically employed for two reasons: (1) to increase coverage, and (2) to improve the handoff process. Where the cell sites are capacity limited, such as in high traffic areas, however, there is

a reduced need for the advantages of soft handoff. As a result, the CDMA networks continue to have limited capacity.

Therefore, a need exists to increase the capacity of the CDMA networks deployed at a single frequency.

5

SUMMARY OF THE INVENTION

Systems and methods consistent with the principles of the present invention address this need by taking advantage of the additional available frequencies and utilizing hard handoff mechanisms to increase the capacity of individual sectors and cell sites.

10 In accordance with the purpose of the invention as embodied and broadly described herein, the system consistent with the principles of the present invention increases the capacity of a CDMA network having a plurality of cell sites. The system defines a pool of frequencies available for assignment, and assigns one of the available frequencies to each of the cell sites so as to minimize the number of neighboring cell sites assigned a same one of the available
15 frequencies. By deploying different frequencies in the cell sites, the amount of interference caused by neighboring cell sites reduces. As a result, the capacity of each of the cell sites operating at a single frequency can be increased, so long as there remains sufficient power to reach the mobile units operating within the cell site.

20

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate an embodiment of the invention and, together with the description, explain the objects, advantages, and principles of the invention. In the drawings,

5 Fig. 1 is a graph of the frequency reuse factor as a function of the pathloss exponent obtained by considering a hexagonal arrangement of cell sites in a CDMA network deployed at a single frequency;

 Figs. 2A and 2B are a flowchart of a method of increasing the capacity of a CDMA network in a manner consistent with the principles of the present invention;

10 Fig. 3 is a diagram of an extension of effective cell site coverage occurring as a result of deploying different frequencies in a manner consistent with the principles of the present invention;

 Fig. 4 is a diagram showing an example in which a mobile or portable unit moves between cell sites operating at different frequencies;

15 Fig. 5 is a graph of the frequency reuse factor as a function of the pathloss exponent and the number of deployed frequencies in a CDMA network consistent with the principles of the present invention;

 Fig. 6 is a diagram of an example of a frequency plan having two deployed frequencies;

 Fig. 7 is a diagram of an example of a frequency plan having four deployed frequencies;

20 and

 Fig. 8 is a diagram of an example of a frequency plan having six deployed frequencies.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The following detailed description of the invention refers to the accompanying drawings. The description includes exemplary embodiments, other embodiments are possible, and changes may be made to the embodiments described without departing from the spirit and scope of the invention. The following detailed description does not limit the invention. Instead, the scope of the invention is defined by the appended claims.

Over the last several years, the hard handoff feature of CDMA has dramatically improved due to the increased need to be able to handoff to other CDMA operators at the borders of the CDMA network, and due to cases where the CDMA network operates at multiple layered frequencies to reduce the interference between newly deployed networks and incumbent microwave operators.

Systems and methods consistent with the principles of the present invention increase the capacity of CDMA networks by deploying adjacent cell sites at different frequencies, and using hard handoff mechanisms between the cell sites, if necessary, as a mobile or portable unit travels across the network.

Figs. 2A and 2B are a flowchart of a method of increasing the capacity of a CDMA network in a manner consistent with the principles of the present invention. The method is executed by a computer system, such as a personal computer or a larger main frame computer. The computer system operates on a simulated CDMA network to increase its capacity for use in a real CDMA network deployment. While systems and methods consistent with the principles of the present invention will be described as increasing the capacity of a simulated CDMA network

for deployment of a real CDMA network, the systems and methods could also be used as a network manager to dynamically update an existing CDMA network.

The computer system begins the method by defining the CDMA network coverage area [step 2110]. Defining the CDMA network coverage area includes identifying the cell sites, including CDMA border and beacon cell sites, spreading CDMA traffic, and setting CDMA parameters. Spreading the CDMA traffic entails designating a traffic map for the network so as to distribute the anticipated CDMA network traffic across the best serving areas of all of the cell sites and sectors. The CDMA parameters include power settings for all of the channels, antenna gain, cable loss, handoff thresholds, *etc.*

Once the CDMA network coverage area is defined, the pool of available frequencies is defined [step 2120]. The number of frequencies in the frequency pool is user-selected. After the available frequency pool has been defined, the system assigns each cell site a single frequency from the frequency pool. The system does this by selecting a cell site for assignment [step 2130], and determining whether the cell sites neighboring the selected cell site have already been assigned frequencies [step 2140]. If none of the neighbor cell sites have been assigned frequencies, the system assigns a frequency from the frequency pool to the selected cell site [step 2150]. This assignment might be made by randomly selecting a frequency from the pool of available frequencies.

If some of the neighbor cell sites have already been assigned frequencies, the system determines what frequencies have been assigned to these neighbor cell sites [step 2160]. Based on this determination, the number of frequencies available from the frequency pool, the pathloss, the traffic environment, *etc.*, the system assigns a frequency to the selected cell site [step 2170].

The system assigns this frequency so as to minimize the number of neighbor cell sites that are assigned the same frequency.

Once the selected cell site is assigned a frequency, the system determines whether all of the cell sites in the CDMA network have been assigned frequencies [step 2210] (Fig. 2B). If
5 some of the cell sites have not been assigned frequencies, the system returns to step 2130 where it selects the next cell site for frequency assignment. If all of the cell sites have been assigned frequencies, however, the system measures the amount of interference occurring at each cell site caused by neighbor cell sites that operate at the same frequency [step 2220].

Based on whether the amount of interference caused by neighbor cell sites is acceptable,
10 maybe based on comparison to a predetermined threshold, the system determines whether the pool of available frequencies should be increased [step 2230]. If the frequency pool should be increased, the system returns to step 2120 where the user redefines the pool of available frequencies. If the frequency pool is not to be increased, the frequency assignment is determined to be acceptable and the method ends.

15 By using different frequencies in a manner consistent with the principles of the present invention, the effective coverage of a cell site can be extended. Fig. 3 is a diagram of the extension of effective coverage occurring as a result of deploying different frequencies consistent with the principles of the present invention. The larger "discs" 3100, 3200, and 3300 represent cell sites operating at similar frequencies.

20 The frequency and placement, according to principles of the present invention, are such that hard handoff mechanisms are used to traverse between cell sites. Fig. 4 is a diagram showing an example in which a mobile or portable unit moves between cell sites operating at

different frequencies. Fig. 4 shows three cell sites 4110, 4120, and 4130, and mobile unit 4200 originally located in cell site 4110. Cell sites 4110 and 4130 operate at frequency F1. Cell site 4120, located between cell sites 4110 and 4130, operates at frequency F2.

As mobile unit 4200 traverses cell site 4120 on its way to cell site 4130, one of two things can occur. If the signals from cell sites 4110 and 4130 are sufficiently strong, mobile unit 4200 performs a soft handoff from frequency F1 used by cell site 4110 to frequency F1 used by cell site 4130 without having to perform a hard handoff to frequency F2 used by cell site 4120. If, however, the signals from cell sites 4110 and 4130 are not strong, mobile unit 4200 performs a hard handoff from frequency F1 used by cell site 4110 to frequency F2 used by cell site 4120. If this occurs, mobile unit 4200 also performs a hard handoff to frequency F1 used by cell site 4130 after mobile unit 4200 enters cell site 4130.

Thus, a mobile or portable unit traversing the network can perform a soft handoff between cell sites operating at the same frequency or a hard handoff to a neighboring cell site operating at a different frequency.

By increasing the pool of frequencies available for assignment, as described above, the amount of interference between cell sites reduces and the capacity on the deployed frequencies increases. Fig. 5 is a graph of the frequency reuse factor as a function of the pathloss exponent and the number of deployed frequencies in a CDMA network consistent with the principles of the present invention. Line 1 represents a frequency pool including a single frequency, similar to the graph shown in Fig. 1, line 2 represents a frequency pool having two frequencies, line 3 represents a frequency pool having four frequencies, and line 4 represents a frequency pool including six frequencies.

When a single frequency is deployed (line 1), the frequency reuse factor for a low pathloss exponent of 2, for example, can be as low as 20 to 30%, depending on shadowing and the specific handoff parameter settings. This means that most of the potentially usable signal at the base station receiver is actually interference from mobile units in other cell sites rather than signals from within the same cell site. By doubling the frequency pool (line 2), the cell site capacity increases by approximately 75% for a pathloss exponent of 2. Further increasing the frequency pool to four (line 3) or six (line 4) frequencies increases the cell site capacity for a pathloss exponent of 2 by approximately 180 to 220%, respectively.

The benefits may not be as dramatic at higher pathloss exponent values. For example, for a pathloss exponent of 4, the frequency reuse factor for a single deployed frequency is approximately 65 to 70%. When two, four, or six frequencies are deployed, the cell site capacity increases by approximately 25 to 45%, respectively.

Figs. 6 through 8 are diagrams of frequency plans having two, four, and six deployed frequencies, respectively. These figures show the hexagonal arrangement of cell sites operating at a similar frequency for two frequencies (Fig. 6), four frequencies (Fig. 7), and six frequencies (Fig. 8).

Systems and methods consistent with the principles of the present invention increase cell site capacity in a CDMA network by deploying multiple frequencies and utilizing hard handoff mechanisms between cell sites.

The systems and methods consistent with the principles of the present invention are applicable to both forward and reverse CDMA channels, and find maximum benefit in microcellular scenarios where the pathloss exponent is low and there is sufficient traffic to

warrant the deployment of additional frequencies, and where frequency resources are not an issue, such as at Personal Communications Services (PCS) frequencies.

The foregoing description of preferred embodiments of the present invention provides illustration and description, but is not intended to be exhaustive or to limit the invention to the
5 precise form disclosed. Modifications and variations are possible in light of the above teachings or may be acquired from practice of the invention. The scope of the invention is defined by the claims and their equivalents.

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WHAT IS CLAIMED IS

1. A method for increasing capacity of a digital wireless network having a plurality of cell sites, comprising the steps of:

defining a pool of frequencies available for assignment; and

5 assigning one of the available frequencies from the frequency pool to each of the cell sites based on frequencies assigned to neighboring cell sites to minimize a number of neighboring cell sites assigned a same one of the available frequencies.

2. The method of claim 1, wherein the defining step includes the substep of:

10 selecting at least two frequencies from the pool of frequencies available for assignment.

3. The method of claim 1, wherein the assigning step includes the substeps of:

selecting one of the cell sites,

15 determining frequencies assigned to the cell sites neighboring the selected cell site, and

assigning one of the available frequencies to the selected cell site based on the determined frequencies assigned to the neighboring cell sites.

20 4. The method of claim 1, wherein the assigning step includes the substep of:

determining an amount of interference at the cell sites caused by the neighboring cell sites after assigning frequencies to all of the cell sites.

5. The method of claim 4, wherein the assigning step further includes the substeps
of:

comparing the determined interference amount to a predetermined threshold,
increasing the pool of frequencies available for assignment when the determined

5 interference amount is greater than the predetermined threshold, and

assigning the increased pool of available frequencies to the cell sites so as to
minimize the number of neighboring cell sites assigned a same one of the available
frequencies.

10 6. The method of claim 1, further comprising the step of:

identifying a coverage area of the network; and

wherein the defining step includes the substep of:

selecting the frequencies available for assignment based on the identified coverage
area of the network.

7. A system for increasing capacity of a digital wireless network having a plurality of cell sites, comprising:

a frequency defining component to define a pool of frequencies available for assignment;

and

5 an assignment component to assign one of the available frequencies from the frequency pool to each of the cell sites based on frequencies assigned to neighboring cells sites to minimize a number of neighboring cell sites assigned a same one of the available frequencies.

8. The system of claim 7, wherein the frequency defining component includes:

10 a selection component to select at least two frequencies from the pool of frequencies available for assignment.

9. The system of claim 7, wherein the assignment component includes:

a selection component to select one of the cell sites,

15 a determination component to determine frequencies assigned to the cell sites neighboring the selected cell site, and

a frequency assignment component to assign one of the available frequencies to the selected cell site based on the determined frequencies assigned to the neighboring cell sites.

20 10. The system of claim 7, wherein the assignment component includes:

a determination component to determine an amount of interference at the cell sites caused by the neighboring cell sites after assigning frequencies to all of the cell sites.

11. The system of claim 10, wherein the assignment component further includes:

5 a comparison component to compare the determined interference amount to a predetermined threshold,

a frequency component to increase the pool of frequencies available for assignment when the determined interference amount is greater than the predetermined threshold, and

10 a frequency assignment component to assign the increased pool of available frequencies to the cell sites so as to minimize the number of neighboring cell sites assigned a same one of the available frequencies.

12. The system of claim 7, further comprising:

15 a network coverage component to identify a coverage area of the network; and wherein the frequency defining component includes:

a frequency selection component to select the frequencies available for assignment based on the identified coverage area of the network.

13. A computer program product for increasing capacity of a digital wireless network having a plurality of cell sites, comprising:

a frequency defining module to define a pool of frequencies available for assignment; and

an assignment module to assign one of the available frequencies from the frequency pool

5 to each of the cell sites to minimize a number of neighboring cell sites assigned a same one of the available frequencies.

14. The computer program product of claim 13, wherein the frequency defining module includes:

10 a selection module to select at least two frequencies from the pool of frequencies available for assignment.

15. The computer program product of claim 13, wherein the assignment module includes:

15 a selection module to select one of the cell sites,

a determination module to determine frequencies assigned to the cell sites neighboring the selected cell site, and

a frequency assignment module to assign one of the available frequencies to the selected cell site based on the determined frequencies assigned to the neighboring cell sites.

20

16. The computer program product of claim 13, wherein the assignment module includes:

a determination module to determine an amount of interference at the cell sites caused by the neighboring cell sites after assigning frequencies to all of the cell sites.

5

17. The computer program product of claim 16, wherein the assignment module further includes:

a comparison module to compare the determined interference amount to a predetermined threshold,

a frequency module to increase the pool of frequencies available for assignment when the determined interference amount is greater than the predetermined threshold, and

a frequency assignment module to assign the increased pool of available frequencies to the cell sites so as to minimize the number of neighboring cell sites assigned a same one of the available frequencies.

18. The computer program product of claim 13, further comprising:

a network coverage module to identify a coverage area of the network; and wherein the frequency defining module includes:

a frequency selection module to select the frequencies available for assignment based on the identified coverage area of the network.

19. A method of increasing capacity of a digital wireless network, comprising the steps of:

identifying cell sites of the digital network;

defining a pool of frequencies available for assignment;

5 selecting one of the cell sites;

determining frequencies assigned to the cell sites neighboring the selected cell site; and

assigning one of the available frequencies to the selected cell site based on the determined frequencies assigned to the neighboring cell sites to minimize a number of neighboring cell sites assigned a same one of the available frequencies.

20. A computer-implemented method for optimally increasing capacity of a digital network having a plurality of cell sites, comprising the steps of:

(a) defining a pool of frequencies available for assignment;

(b) selecting one of the cell sites;

5 (c) determining frequencies assigned to the cell sites neighboring the selected cell site;

(d) assigning one of the available frequencies to the selected cell site based on the determined frequencies assigned to the neighboring cell sites;

(e) determining an amount of interference at the cell sites caused by the neighboring cell sites after assigning frequencies to all of the cell sites;

10 (f) comparing the determined interference amount to a predetermined threshold;

(g) increasing the pool of frequencies available for assignment when the determined interference amount is greater than the predetermined threshold; and

(h) repeating steps (d) through (g) using the increased number of available frequencies until the determined interference amount is less than the predetermined threshold.

ABSTRACT

A system increases the capacity of a CDMA network having a plurality of cell sites. The system defines a pool of frequencies available for assignment, and assigns one of the available frequencies to each of the cell sites so as to minimize the number of neighboring cell sites assigned a same one of the available frequencies. By deploying different frequencies in the cell sites, the amount of interference caused by neighboring cell sites reduces. As a result, the capacity of each of the cell sites operating at a single frequency can be increased, so long as there remains sufficient power to reach the mobile units operating within the cell site. The system attains maximum benefits when the cell sites are located close together and the propagation exponent is low (for example, 10-20 dB/decade).

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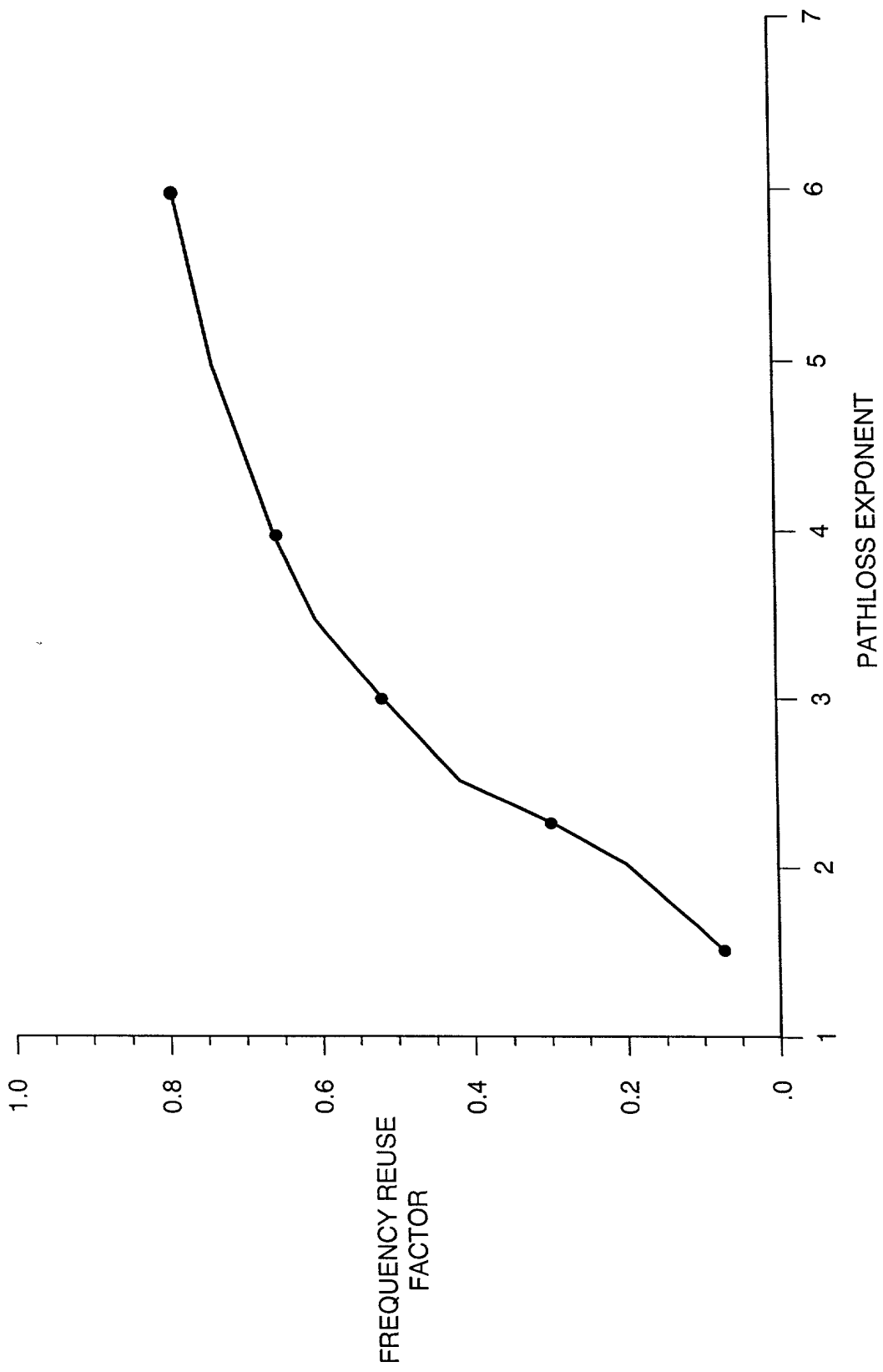
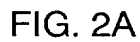


FIG. 1

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100	100	100



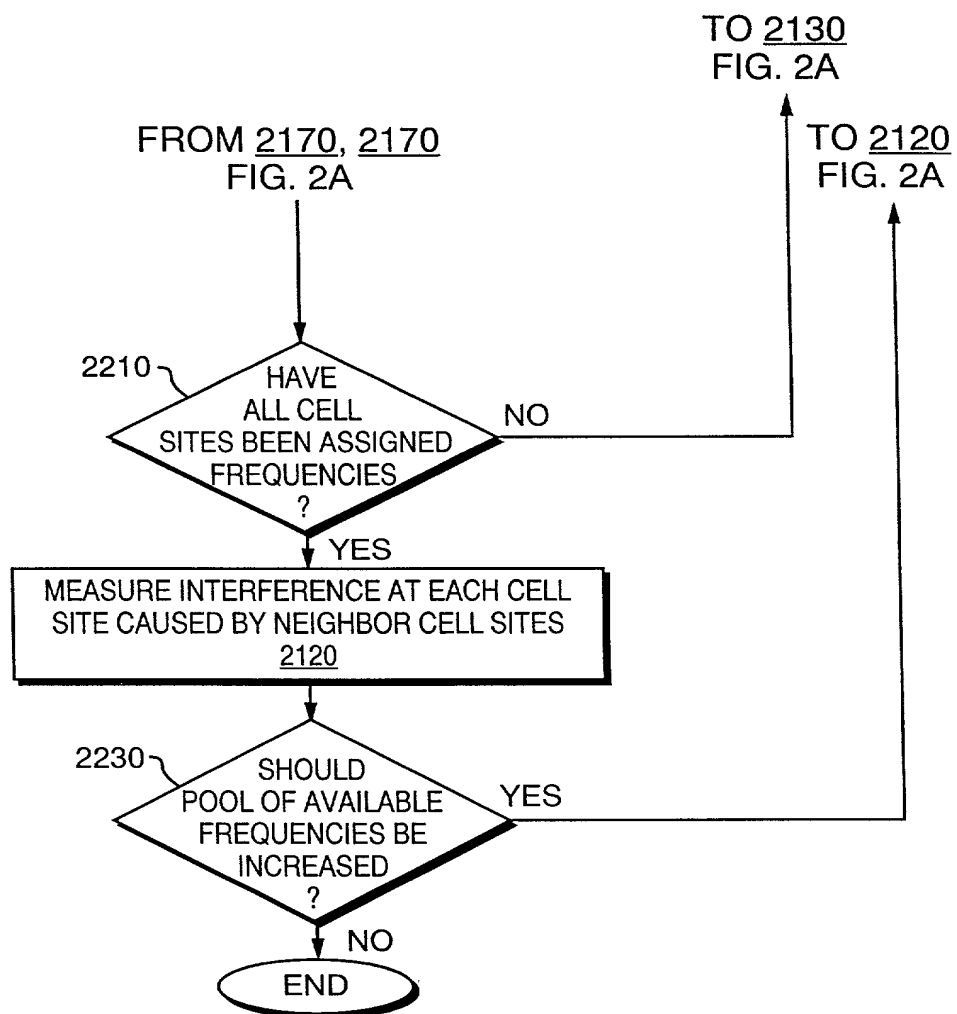


FIG. 2B

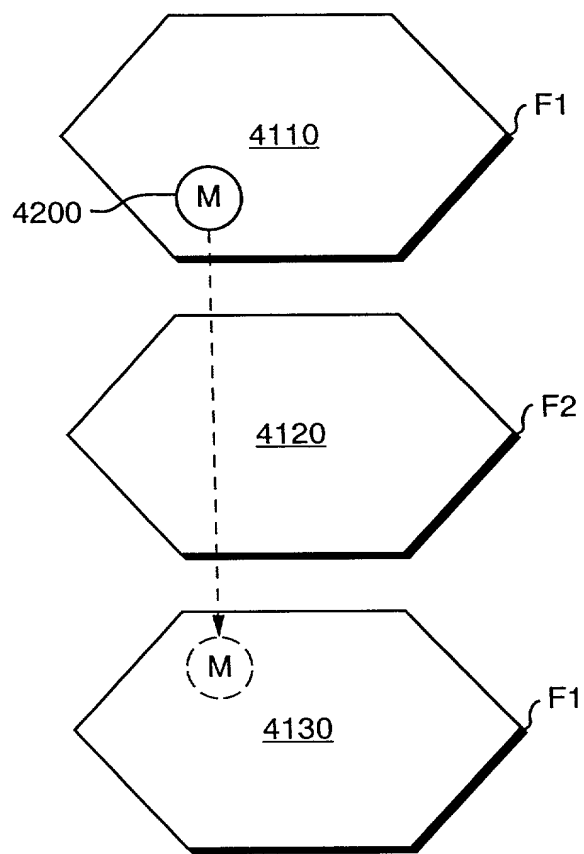


FIG. 4

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2 FREQUENCIES

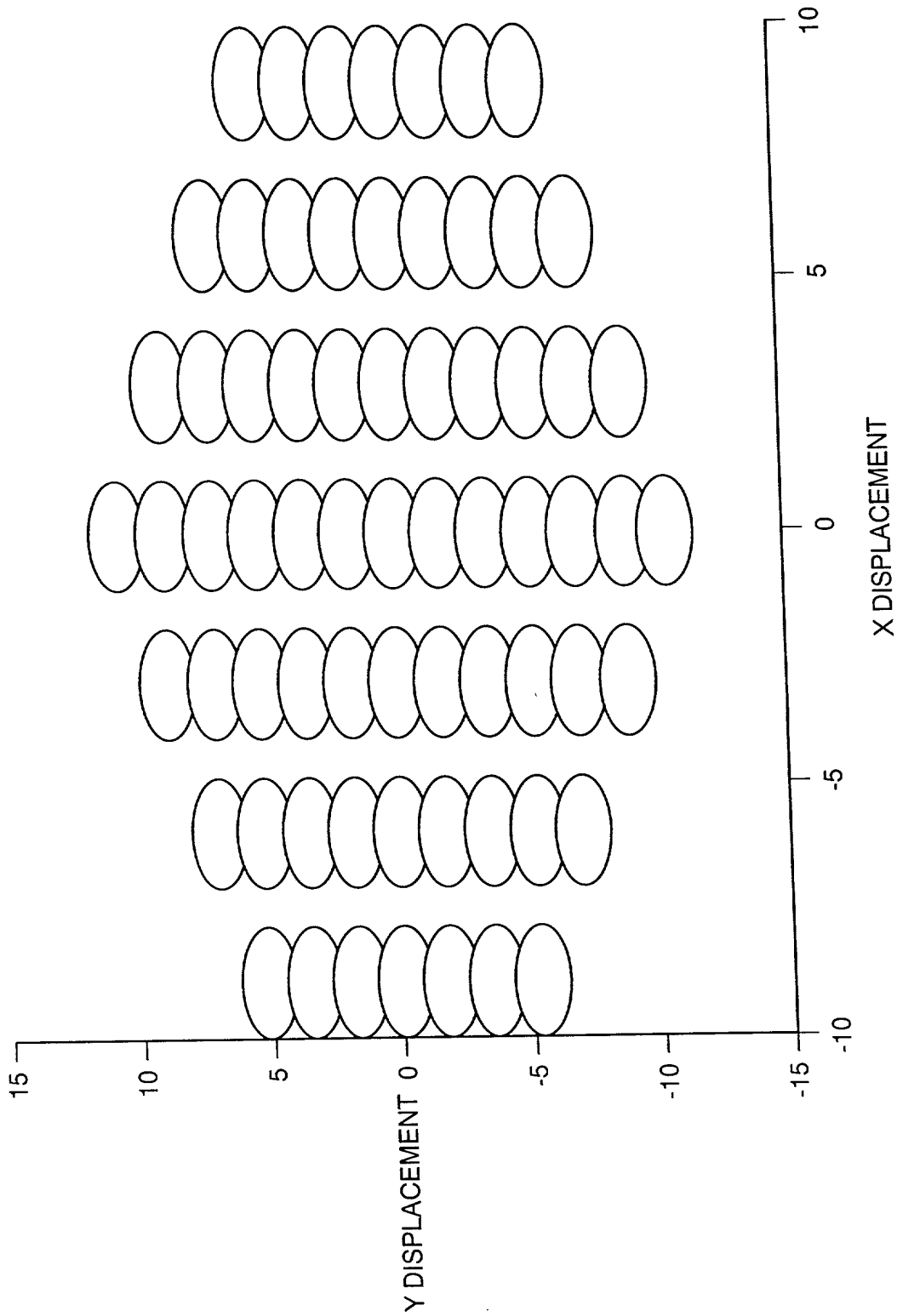


FIG. 6



002250* 62020900



4 FREQUENCIES

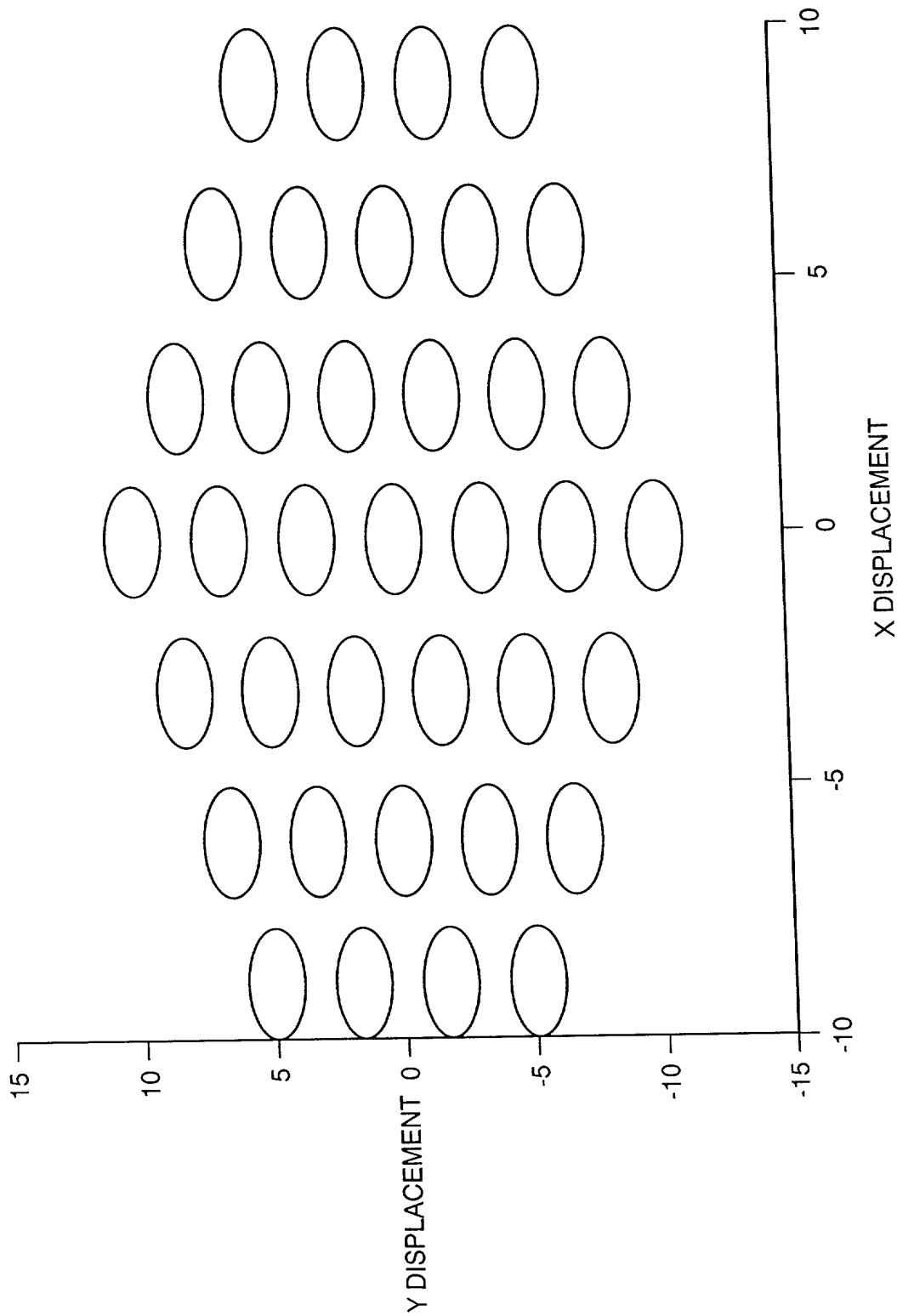


FIG. 7



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6 FREQUENCIES

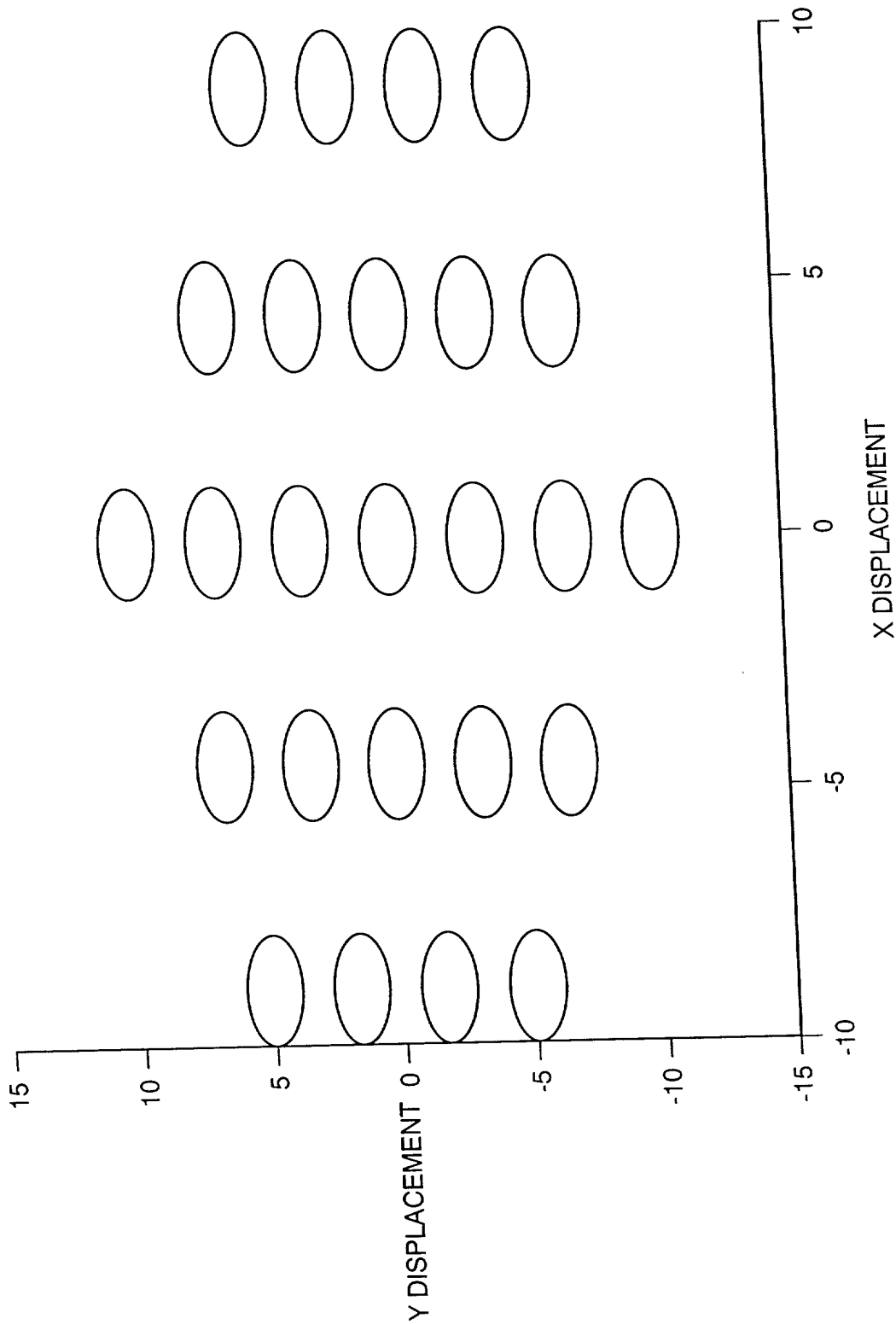


FIG. 8



DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

Attorney Docket No. 97-3-802

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

**SYSTEM AND METHOD FOR INCREASING CDMA CAPACITY
BY FREQUENCY ASSIGNMENT**

the specification of which (check one) ☒ is attached hereto. ☐ was filed on
as Appln. Serial No. _____ and was amended on _____
(if applicable). I hereby state that I have reviewed and understand the contents of the above identified
specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the patentability of this application
in accordance with Title 37, Code of Federal Regulations, Section 1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119 of any foreign
application(s) for patent or inventor's certificate listed below and have also identified any foreign
application for patent or inventor's certificate having a filing date before that of the application on
which priority is claimed:

Prior Foreign Application(s)

Priority Claimed

(Number)

(Country)

(Day/Month/Year filed)

☐ Yes ☐ No

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States
application(s) listed below and insofar as the subject matter of each of the claims of this application is
not disclosed in the prior United States application in the manner provided by the first paragraph of Title
35, United States Code, Section 112, I acknowledge the duty to disclose material information as defined
in Title 37, Code of Federal Regulations, Section 1.56 which occurred between the filing date of the
prior application and the national or PCT international filing date for this application:

(Appln. Serial No.)

(Filing Date)

(Status--patented, pending, abandoned)

I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and to transact all
business in the Patent and Trademark Office connected therewith:

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Attorney Docket No.

97-3-802

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Date _____

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Citizenship

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